FINAL REPORT

on

Contract No. 0SQ82-00152
Department of Energy, Mines and Resources

"Development of a Portable Underground Environment Air Quality Monitoring System"

by

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MICROMEDIA

INTRODUCTION

A portable monitoring system (PMS) has been designed, assembled and shipped to CANMET. This portable instrument package was designed after the portable analysis system used by Michigan Technological University on the United States Bureau of Mines sponsored underground diesel mine air monitoring research project.

The work was carried out in accordance with the following statement of work:

The contractor shall develop a portable instrumentation package incorporating CO, CO_2, NO, NO_2, and particulate matter monitoring systems for use in the underground environment. The minimum requirement is that the package will provide time-weighted averages of the constituents involved or real-time (continuous) values of the constituents where possible. The objective is that not only the individual constituent levels will be determinable but also the overall quality of the environment can be assessed using the Air Quality Index Criterion.

This work shall be phased as follows:

1. Preliminary design phase to be completed by October 29, 1982.
2. Confirmation of the design by consultative meeting with the Scientific Authority by October 29, 1982.
3. Acquisition, fabrication and assembly and performance trials completed by February 28, 1983.
4. Completed report including drawings plus the developed equipment to be delivered to the Scientific Authority by March 31, 1983.

PORTABLE MONITORING SYSTEM COMPONENTS

The PMS contains apparatus for simultaneous measurement of the TWA concentrations of CO, CO_2, NO, NO_2, and particulate matter at more than one underground location. These TWA concentrations are measured as follows:

CO and CO_2

A Dupont pl25 pump draws mine air at 25-125 cc/minute through a particulate removal filter into a Calibrated Instruments 22-liter snout type 5-layer bag. The particulate filter, pump, and bag are protected from damage by a custom made bag-sampling case. The flow rate is set to provide sufficient sample for analysis by connecting the bag to recently calibrated Fuji ZFP5 NDIR CO_2 and Ecolyzer 2106 electrochemical CO instruments.

NO and NO_2

Passive personal samplers (tubes containing chemically-coated screens to collect NO_2) are made up in the laboratory within a few days of their intended use. A chromic acid disk is inserted in those samplers which are to be used to collect both NO and NO_2 (NO_X) within 24 hours prior to their use. This disk oxidizes NO to NO_2 so that it also collects on the screens. Samplers for NO and NO_X are exposed simultaneously by removal of caps covering the ends of the tubes containing the chemically-coated screens. Both the diameters of the tubes and distances from the open end to the screens have been carefully fixed so that the quantity of NO_2 which diffuses to the screens is proportional to the concentration in the mine air at the open end (based on Ficks law).

The quantity of NO_2 dissolved on the screens is determined for each sampler by dissolution and colorimetric analysis using a Sequoia Turner Model 340 Spectrophotometer.

Because the accuracy of the samplers is somewhat affected by the particular diesel exhaust, one set of both types of samplers is exposed alongside an Ecolyzer 7230 continuous NO/NO_2 Analyzer. The NO and NO_2 concentrations from the Ecolyzer are recorded on a pair of Rustrak strip chart recorders. Correction factors are developed from these comparisons and these factors are used to correct the concentrations measured by other samplers exposed to similar diesel emissions.

Particulate Matter

Mine air is drawn through a respirable dust head assembly to remove "nonrespirable" particulate matter by collection in the removable bottom of a 10mm nylon cyclone. The air which then contains "respirable" particulate matter only passes through a cassette (field monitor) containing a preweighed 37mm Gelman A/E glass fiber filter disk which is supported on a 37mm stainless steel support screen. The quantity of particulate matter collected is determined by reweighing the filter and calculating the increase in weight. The mine air particulate matter concentration is determinable by using a Bendix C115 or Dupont P4000 pump operated at an accurately calibrated flow rate which is set to provide a specific "respirable/nonrespirable" cutoff size.

Because the quantities of particulate matter collected are small, small changes in the moisture content of the filters can result in significant weighing errors. Therefore, the sample is

conditioned prior to each weighing in a manostat glove box, the relative humidity of which is controlled to about 45% by solid zinc nitrate in contact with water contained in pyrex pans. The manostat also houses the Perkin Elmer weighing module of the AD-2B ultramicrobalance used to weigh the filters.

The Gelman A/E glass fiber filters have a relatively low and fairly constant background level of organic material and these filters can be analyzed for respirable combustible dust. Presently it is the practice at Michigan Technological University to analyze these samples with a Perkin Elmer Model 240 CHN Analyzer and to assume the concentrations of the carbon + hydrogen are equal to the concentrations of diesel particulate in the mine air. There are also other ways to determine the respirable combustible dust content, such as combusting the filters at a set temperature for a specific time under a controlled atmosphere. The assumption about the carbon + hydrogen concentration being equal to the diesel particulate matter concentration is only true where the collected dust contains carbon from no other source. If this is not the case the results must be corrected for this additional source of carbon.

The instrument package provided for CANMET contains all the components required to carry out sampling and analysis as discussed above. Only the particulate filter carbon + hydrogen analysis will require additional apparatus to perform.

A complete inventory list of equipment and supplies is contained in Table 1. Appendix 1 lists the names and addresses of Vendors for most of these items. Features and specifications

TABLE 1

INVENTORY OF EQUIPMENT

FOR CANMET PORTABLE MONITORING SYSTEM

Carton No.	No. of Items	Item	Value U.S. Dollars Unit	Value U.S. Dollars Total	Application
15 & 16	2	Bag sampling cases - custom made	$500.00	$1000.00	Wood box to protect bags and pumps while sampling
17	3	P4000 Constant-flow samplers with chargers	990.00	2970.00	High flowrate dust sampling pumps
17	3	P125A constant-flow samplers with chargers	610.00	1830.00	Low flowrate gas sampling pumps
18	1	Ecolyzer 2106 carbon monoxide monitor	1900.00	1900.00	Portable carbon monoxide measurement instrument
13	1	Ecolyzer 7230 NO/NO_2 analyzer	3600.00	3600.00	Portable NO/NO_2 measurement instrument
12	5	Ecolyzer 2952 2-liter sample bags	8.00	40.00	Bags to feed calibration gases to instruments
22	2	Ecolyzer 7921 NO interference filters	30.00	60.00	Filter out gases that cause incorrect instrument readings
22	2	Ecolyzer 7922 NO_2 interference filters	30.00	60.00	(Same as above)
22	10	Ecolyzer 2920 CO interference filters	6.00	60.00	(Same as above)
22	3	BDX 99 Respirable dust lapel samplers	75.00	225.00	Dust filter-cassette holder and coarse dust remover
22	1	BDX 99 Cyclone in side-arm tube	100.00	100.00	Pump calibration setup to simulate sampling pressure drop
10	1	ECC 4-07-100 pump calibrator	42.00	42.00	Bubble meter - used with watch to measure flow rate
24	1	ECC 4-07-2000 pump calibrator	97.00	97.00	(Same as above)
22	1	Gelman 61652 A/E glass fiber filters (500 disks)	58.62	58.62	Dust filters used to measure dust concentrations
15	4	Gelman 7231 Analyslide (Pkg. of 100)	25.00	100.00	Plastic holders to store weighed filters
12	2	Bendix C115 Pump, charger, & filter holder assembly	1736.00	3472.00	High-flowrate, rugged dust sampling pumps
34	1	Al cylinder 40 ppm $CO/0.4\%$ CO_2 in N_2 (incl. deposit)	226.00	226.00	Gas to calibrate CO and CO_2 instruments
2	2	Model 51-02B-350 Regulator for CO/CO_2	103.00	206.00	Measure and control gas cylinder pressure
35	1	Al cylinder Ultrazero nitrogen (incl. deposit)	210.00	210.00	Gas to zero all instruments
2	1	Model 51-02B-580 Regulator for N_2	103.00	103.00	Measure and control gas cylinder pressure
36	1	Al cylinder 40 ppm NO in N_2 (incl. deposit)	250.00	250.00	Gas to calibrate NO instrument
37	1	Al cylinder 4 ppm NO_2 in N_2 (incl. deposit)	330.00	330.00	Gas to calibrate NO_2 instrument
2	2	Model 51-13A-660 Regulators for NO/NO_2	275.00	550.00	Measure and control gas cylinder pressure
32	1	Gas transfer apparatus	283.00	283.00	Transfer gas from large to small cylinder
32	4	D-size alloy steel cylinders (2 w/stainless steel valves & 2 w/brass valves)	2/100.00 2/ 62.50	325.00	Small cylinders for field instrument calibration
32	4	Model 51-406 T control valves w/gages	62.00	248.00	Valve and pressure gauge for small cylinders
32	1	GCA 350 Fittings	7.00	7.00	Various connections for gas transfer
32	1	GCA 580 Fittings	7.00	7.00	(Same as above)
32	2	GCA 660 Fittings	17.50	35.00	(Same as above)
38	1	ZFP5 CO_2 portable analyzer	2195.00	2195.00	Portable carbon dioxide measurement instrument
31	10	Passive personal samplers (10/pkg)	75.00	750.00	Small pin-on NO and NO_2 passive samplers
22	1	Field monitor (filter cassette) (100/pkg)	99.36	99.36	Hold filters during dust sampling
31	1	Screens for passive samplers (200/pkg)	31.50	31.50	Extra parts for NO and NO_2 passive samplers
31	100	Plugs for passive samplers	3.00	300.00	(Same as above)
31	1	Field suitcase for passive samplers	150.00	150.00	Carrying case for NO and NO_2 passive samplers
21	1	NBS 25 ppm CO in N_2, SRM 2635	484.00	484.00	Standard gas to assure calibration-gas accuracy
19	1	NBS 0.5% CO_2 in N_2, SRM 2619A	545.00	545.00	(Same as above)
20	1	NBS 20 ppm NO in N_2, SRM 2629	690.00	690.00	(Same as above)
32	1	Portable cylinder case, custom made	500.00	500.00	Wood case to carry four D-size cylinders

TABLE 1

INVENTORY OF EQUIPMENT (CONT.)

Carton No.	No. of Items	Item	Value U.S. Dollars Unit	Value U.S. Dollars Total	Application
27-30	4	Model 288 Rustrak recorders	$321.00	$1284.00	Record measurements from portable instruments
2	3	Spare meter movements (Rustrak recorders)	101.28	303.84	Extra parts for recorders
11	40	Rolls WA-A chart paper (Rustrak recorders)	5.20	208.00	Chart paper for recorders
27-30	4	PS1265 Gel-type batteries	27.15	108.60	Batteries to power recorders
27-30	4	PSC12500-F Chargers (Gel-type batteries)	27.47	109.88	Charge recorder batteries
27-30	4	Boxes set-up for recorders, batteries, charger	20.00	80.00	U.S. Army surplus boxes to hold recorder, battery, & charger
14	1	Mettler AE-160 Electronic balance	2795.00	2795.00	NO/NO_2 passive sampler makeup/analysis
5	1	Sequoia Turner Model 340 Spectrophotometer	995.00	995.00	(Same as above)
5	1	Square cuvet adaptor for 340 spectrophotometer (attached)	175.00	175.00	Adaptor for Sequoia Turner spectrophotometer
26	1	Manostat glove box	925.00	925.00	Store dust filters at constant relative humidity
26	1	Front glove box closures (Pkg. of 2)	54.12	54.12	Plastic cover for manostat openings
4	1	10 mm square disposable cuvets (pkg of 500)	46.65	46.65	NO/NO_2 passive sampler makeup/analysis
1	1	Interval timer	38.51	38.51	(Same as above)
1	1	Parafilm	10.84	10.84	(Same as above)
26	1	Durotherm hygrometer	82.51	82.51	Humidity gage for manostat glove box
1	1	Oxford model M dispensor/bottle	65.00	65.00	NO/NO_2 passive sampler makeup/analysis
1	1	Glass fiber filters, Whatman 934AH - 7 cm	14.51	14.51	(Same as above)
2	2	Fluoroglide, CP Grade	5.79	11.58	Lay non-sticking film on dust filter cassettes
3	1	$Zn(NO_3)_2 \cdot 6H_2O$, 5 lb.	62.25	62.25	Control manostat glove box relative humidity
8	1	H_3PO_4, 8 lb	31.71	31.71	NO/NO_2 passive sampler makeup/analysis
1	1	NEDA, 25 g	49.49	49.49	(Same as above)
1	1	Sulfanilamide, 500 g	29.60	29.60	(Same as above)
9	1	H_2SO_4, 9 lb.	16.71	16.71	(Same as above)
1	1	Triethanolamine, 250 g	20.95	20.95	(Same as above)
7	1	$Na_2Cr_2O_7$, 500 g	43.40	43.40	(Same as above)
25	1	20 microliter micropipettor	35.75	35.75	(Same as above)
25	1	Box of 1000 disposable tips	32.50	32.50	(Same as above)
23	1	Spatula	0.71	0.71	(Same as above)
23	2	50 ml volumetric flasks	5.49	10.98	(Same as above)
23	2	100 ml volumetric flasks	6.60	13.20	(Same as above)
23	2	1 liter volumetric flasks	17.53	35.06	(Same as above)
23	2	10 ml beakers	0.98	1.96	(Same as above)
23	2	100 ml beakers	0.91	1.82	(Same as above)
23	2	1 ml volumetric pipettes	2.19	4.38	(Same as above)
23	2	10 ml volumetric pipettes	1.62	3.24	(Same as above)
23	2	5 ml graduated pipettes	2.53	5.06	(Same as above)
22	2	Boxes of disposable gloves	3.00	6.00	(Same as above)
23	1	Test-tube rack	3.96	3.96	(Same as above)
23	10	Package of labels	0.13	1.30	(Same as above)
23	2	2" watch glasses	0.22	0.44	(Same as above)

TABLE 1

INVENTORY OF EQUIPMENT (CONCL.)

Carton No.	No. of Items	Item	Value U.S. Dollars Unit	Value U.S. Dollars Total	Application
22	50	Support screens for aerosol filtration	5.35	267.00	Support filters in cassettes during dust sampling
16	5	22-liter snout-type 5-layer bags	18.70	93.50	Collect gases for analysis for CO and CO_2
6	1	Perkin Elmer AD-2B Electronic ultramicrobalance	5450.00	5450.00	Weigh dust filters before and after sampling
6	2	Stirrup 56 mm for filter weighing	48.00	96.00	Part for dust filter weighing
31	1	7/16" gasket punch to cut chromic acid disks	11.00	11.00	NO/NO_2 passive sampler makeup/analysis
25	1	TI-55-II Calculator	41.57	41.57	(Same as above)
31	1	Dissecting needle with bent tip (screen hook)	2.00	2.00	(Same as above)
33	1	Shelves for manostat	100.00	100.00	Hold filters during manostat storage
25	3	Pans for chemicals - manostat (Pyrex w/fabricated covers)	35.00	105.00	Hold zinc nitrate relative humidity chemical
15	6	Rubber tie-downs (rubber hold-down straps)	1.67	10.00	Fasten bag sampling case to mine vehicle
25	1	6 x 12-inch section of 10 mesh stainless steel screen	10.00	10.00	NO/NO_2 passive sampler makeup/analysis

which were considered in the selection of the largest items - ultramicrobalance, analytical balance, and spectrophotometer are listed in Tables 2 through 4.

Most other items selected were either the most suitable of the various alternatives or the only one(s) available.

PERFORMANCE TESTS

Tests were made to the extent deemed necessary to assure that the various instruments and other apparatus performed satisfactorily. For some items it was necessary only to assemble the apparatus and try it out. Other items required only visual inspection. Test results for items which required a more detailed evaluation are covered in Appendix II.

SAFETY CONSIDERATIONS

The safety considerations which we believe deserve the greatest amount of attention are the gas transfer operation, gas bottle handling and transportation and explosive mine atmospheres. It is extremely important for the safety of the user of this equipment that adequate training be provided in these areas prior to use of the equipment supplied.

There are a number of errors which can occur while working with high pressure gases that can result in dangerous explosions. It is especially worthy of mention that the gas transfer apparatus supplied should never be used to transfer oxygen. It is, therefore, extremely important to carefully check the contents of both the full and empty cylinders before any transfer is made. Only special regularly hydrostatically-tested cylinders will withstand the high pressures and no portable cylinders other than those supplied by us should be used.

Table 2
Microbalance Features and Specifications

Features & Specifications	Mettler		Cahn			Perkin Elmer		Desirable Features and Specifications
	M3	UM3	C-29	C-28	C-27	AD-2B	AD-2Z	
Range	0-150µg+ Tares to 2990	0-15mg Tares to 2995	0-25mg, 0-1250mg 0-250mg	0-200, 0-1000mg	0-2, 0-20, 0-200 0-1000mg	0-2, 2-20, 2-200mg →		200mg max & 50mg single tare range
Sensitivity	1µg	.1µg	0.1µg	1µg	0.1µg	0.1µg →		Need less than 10µg
Capacity	3.05g	3.005g	3.5g	3.5g	3.5g	5g →		More expands utility - Filters all below 1g
Reproducibility	±1µg	.2µg	0.3µg	3µg	0.3µg	0.5ppm (.05µg most sensitive range) →		Need less than ±10µg
List Price	$7335	$8495	$6390-VWR	$5390-VWR	$5990-VWR	$5450	$5950	Lowest with desirable features $6290 budget
No. of Modules	1	1	1	1	2	2	2	1-Portability, 2-Constant humidity weighing
Auto-Zero	No	No	No	No	No	No	Yes	Not necessary or desirable for weighing filters
Auto-ranging	No	No	No	No	No	Yes	Yes	Not necessary for weighing filters of relatively uniform weight
Portable	Yes	Yes	Yes	Yes	No	No	No	Portability desirable but not usually necessary
Constant Humidity Weighing	Won't fit in Manostat →		Won't fit in Manostat →		Weighing module fits into manostat	Weighing module fits into manostat →		Should fit into manostat glove box
Size	16.8"x10.7"x8.5" →		16.5"x11.8"x9.1" →		9.1"x9.4"x5.1"	9.8"x7.1"x4.7"		Must fit into manostat ports.
Auto Weighing	Yes	No	Yes	Yes	Yes	Yes	Yes	
Warranty	1 yr. USA	1 yr. USA	ND	ND	ND	1 yr. USA	1 yr. USA	If 1 year either USA or Canada, OK
Canadian Service	Fisher Scientific Ottawa (613) 226-8874 →		ND	ND	ND	Perkin Elmer, Toronto →		Needed-Ottawa desirable, Toronto, OK

ND - not determined

(N.D.-not determined)

Table 3. ANALYTICAL BALANCE FEATURES AND SPECIFICATIONS
(All Available from VWR)

Features & Specifications	Torbal EA-1	Mettler AE-160	Mettler AC-100	Mettler H-80	Sartorius H31AR	Sartorius 2462-SR	Sartorius 2842-SR	Sartorius 2432-SR	Desirable Features & Specifications
Type	Hybrid Electronic	Electronic	Electronic	Mechanical	Mechanical	Mechanical Substitution	Mechanical Torsion	Mechanical Substitution	Electronic
Range, g	160	162	82	160	161	200	160	200	At least 160g
Precision, mg	.03	0.1	±.1	±.18	±.05	±.05	±.05	.05	≤ ±.1mg
Capacity, g	160	162	82	160	159	200	160	200	At least 160g
Readability, mg	.05	0.1	.1	.1	.1	.1	0.1	.1	≤ ±.1mg
List Price	$2150	$2795	$2495	$1765	$2445	$2750	$1660	$2445	Budgeted $2150
Portable	No handle	No handle	No handle	No handle	No handle	No handle	No handle	No handle	Not absolutely necessary
Size	12.5"x17.5" x20"	8.1"x16.1" x11.4"	7.4"x11.9" x16.5"	10"x15.4" x16.3"	9.5"x20"x16"	9"x15"x18"	9"x15"x18"	9"x15"x18"	All listed are acceptable
Weighing System	Torsion	Electronic	Electronic						
Special Taring Features	Built in wts. to 159g Alum. pan - 20g	Auto-taring	Auto-taring	None	None	Knob returns back to 0 from any point in Optical range	None	Knob returns balance to 0 from any point in optical renge	Auto taring makes weighing faster, solid state electronic more rugged. Electronic faster to reach equilibrium
Damping	Electronic	Electronic	Electronic	Magnetic	Symmetrical Air	Hydro-dynamic	Hydro-dynamic	Hydro-dynamic	
Canadian Service	N.D.	Fisher Scientific Ottawa (613) 226-8874				N.D.	N.D.	N.D.	Needed - Ottawa desirable
Warranty	N.D.	1 yr. U.S.A.				N.D.	N.D.	N.D.	If 1 yr. either U.S. or Canada O.K.
Other Special Features	Electronic Null indicator	Top Loading	Top Loading	Big Pan	None	Auto Pre-weighing	Auto Pre-weighing	None	Auto-preweighing speeds up weighing. Electronic null indicator. Good top loading easier to use.

NA - not available
ND- not determined

Table 4. Visible Spectrophotometer Features & Specifications

Features & Specifications	(VWR) Bausch & Lomb Spec. 20	Bausch & Lomb Spec. 21-MV	Bausch & Lomb Spec. 21-0V	Bausch & Lomb Spec. 70	(VWR) Sequoia-Turner 340	Sequoia-Turner 350	Sequoia-Turner 380	(Sgt. Welch) Sargent Welch SM	Sargent Welch SD	(VWR) Coleman 295	Coleman 6/20	Coleman 35	Desirable Features & Specifications
Wavelength Range, mm	340→ 950	340→ 1000	340→ 1000	325→ 925	330→ 1000	335→ 1000	320→ 1000	325→ 625	325→ 625	400→ 700	325→ 825	335→ 825	For Palmes 550mm only wavelength used
Photometric Accuracy	N.D.	N.D.	N.D.		±0.5%	±0.5%	N.D.	±0.5%	±0.2%	N.D.	±1%	±0.8%	0.5% seems sufficient
Wavelength accuracy	2.5mm	N.D.	N.D.		±2mm	±2mm	N.D.	±1mm	1%	N.D.	±1mm	±1mm	2mm seems sufficient
Bandwidth	20mm	10mm	10mm	8mm	8mm	8mm	N.D.	10mm	10mm	20mm	20mm	8mm	≤10mm sufficient
Type of Photodetector	N.D.	N.D.	N.D.	Dual tube	Solid state photo cell	Solid state photo cell	Solid state photo cell	Photo tube	Photo tube	N.A.	Solid state photo cell	Photo tube	Photocell sufficient but phototube more sensitive
Type of read out, dig. or analog	Analog	Analog	Dig.	Analog	Dig.	Analog	Dig.	Analog	Dig.	Analog	Analog	Dig.	Digital easier to read accurately
Availability of square cuvette adaptor	Yes	N.D.	N.D.	N.D.	Yes	N.D.	N.D.	Yes (inc.)	Yes (inc.)	N.A.	N.A.	N.A.	Necessary to use with disposable square cuvettes
List price	$875 $20 adaptor	$1094	$1995	$1754	$995 $175 adaptor	$1495	$2100	$1200	$1900	$950	$1525	$1795	Near $1000 budgeted
Special features					direct concentration read out			S-7539-20 direct concentration readout		direct concentration readout			Direct conc. read out, desirable, not necessary
Canadian service	N.D.	N.D.	N.D.		Can. Lab. Ottawa (613) 523-7440			Sgt. Welch Canada		N.D.			Ottawa desirable
Warranty	N.D.	N.D.	N.D.		1 yr. U.S.A.			1 yr. U.S.A.		N.D.			If 1 yr. Canada or USA satisfactory

Only a small number of the instruments provided have been tested for intrinsic safety. Most are not. Even where electrically-powered instruments are labeled intrinsically safe, it is not prudent to knowingly use such apparatus in atmospheres known to contain explosive gas mixtures since a small change in the apparatus may affect this condition.

The above are only a few of the possible hazards. Although we have given considerable thought to safety in the selection of the PMS items we assume no responsibility for accident or injury which may result from its use. It is important rather that the user receive adequate training in the potential hazards and take whatever steps are necessary to guard against them.

RECOMMENDATIONS

It is recommended that individuals only be assigned to use the PMS after adequate training. The training should cover, but not necessarily be limited to, the following areas:

1. Procedures for maintaining the apparatus including storage, calibration, preparation of samplers, laboratory analytical procedures.
2. Procedures for underground mine diesel emission sampling.
3. Procedures for analysis of the results and presentation in a fashion such that conclusions can be made about engineering controls.
4. Training in safe use of the apparatus.

APPENDIX I

List of Vendors

Item Selected in 10/21/82 Design Review Meeting	Item Ordered	Vendor
2 Bag sampling cases (aluminum not suitable)	2 cases constructed from high-grade marine plywood, steel-reinforced and coated with epoxy-type coating inside and out	Eugene Yauch 850 8th St. Lake Linden, MI 49945
3 DuPont P-125 pumps	3 DuPont P-125 pumps	DuPont Applied Tech. Div. Marshall Mill Bldg. Barley Mill Plaza Wilmington, DE 19898
1 ESI 7000 NO/NO_2 instrument	1 Ecolyzer 7230 NO/NO_2 monitor, 10/50 ppm NO, 2/10 ppm NO_2 ranges	Argus Supply Co. 15075 E. Eleven Mile Rd. P.O. Box 689 Roseville, MI 48066
1 Fuji ZFP5 CO_2 monitor	1 part no. 656500 ZFP5 portable CO_2 analyzer, 2000/5000 ppm ranges	MDA Scientific, Inc. 1815 Elmdale Ave. Glenview, IL 60025
1 ESI 2000 CO instrument	1 Ecolyzer 2106 CO monitor, 50/100 ppm ranges	Argus Supply Co. (see above)
NBS gases: CO CO_2 NO	CO - 25 ppm in N_2, SRM 2635 CO_2 - 0.5% CO_2 in N_2, SRM 2619A NO - 20 ppm NO in N_2, SRM 2629	National Bureau of Standards Office of Standard Reference Materials, Rm. B311, Chemistry Bldg., Washington, D.C. 20234
5 Regulators with valves	2 Scott 51-02B-350 for CO/CO_2 1 Scott 51-02B-580 for N_2 2 Scott 51-13A-660 for NO/NO_2	Scott Specialty Gases 1290 Combermere St. Troy, MI 48084
4 Portable cylinders CO/CO_2 NO NO_2 N_2	All Scott D-size alloy steel Brass valve - 350 outlet Stainless steel valve - 660 outlet Stainless steel valve - 660 outlet Brass valve - 580 outlet	Scott Specialty Gases (see above)
4 Control valves with gages for portable cylinders	Scott 51-406T with gages	Scott Specialty Gases (see above)

Item Selected in 10/21/82 Design Review Meeting	Item Ordered	Vendor
Case for portable cylinders (aluminum not suitable)	Custom made wood case-steel reinforced	Eugene Yauch (see above)
Gas transfer apparatus	1 gas transfer apparatus made in accordance with sketch sent with order	Scott Specialty Gases (see above)
4 Strip chart recorders Two 32 inch/hour Two 16 inch/hour	Model 288 Rustrak recorders, 6 volt DC unregulated 16 rpm motors: 2 w/no. 2 and two w/no. 4 gear trains for 16 and 32 inch/hour chart speeds. Meter movements pivot and jewel AA 102-101-1A with three at 0-1 volt and one at 0-100 mV. Also three spare meter movements as above with one 0-100 mV and two 0-1 volt.	Meter Master, Inc. 121 Gordon St. Elk Grove Village, IL 60004
1 Bubble meter apparatus for DuPont P-125A pumps	ECC 4-07-100 pump calibrator	Argus Supply Co. (see above)
4 Gelcell batteries, 6 amp hour rechargeable	PS-1265 Gel-type batteries, Stock No. 621-0365 PSC-12500 F chargers, Stock No. 621-0685	Allied Electronics 1355 N. McLean Blvd. Elgin, IL 60120
4 Cases for recorders and gel-type batteries (U.S. Army surplus ammunition boxes)		Surplus Outlet, Houghton, MI 49931
1 Palmes field kit	10 pkgs of 10 each NO_2/NO_x passive personal samplers 200 extra screens 100 extra plugs	MDA Scientific, Inc. 1815 Elmdale Ave. Glenview, IL 60025

Item Selected in 10/21/82 Design Review Meeting	Item Ordered	Vendor
1 Palmes carrying case	1 complete field suitcase w/insert	MDA Scientific, Inc. (see above)
1 Palmes analysis kit spectrophotometer	1 Sequoia Turnes Model 340 Spectrophotometer, cat. no. 58012-606 1 Cuvet adaptor for same cat. no. 58012-118	VWR Scientific 3140 Grand River Ave. Detroit, MI 48208
Palmes analysis kit: Lab apparatus & chemicals	1 58017-825 pkg of 500 disposable cuvets 1 62348-100 interval timers 1 52858-000 parafilm 4 x 125 labels 1 53519 Oxford model M dispensor bottle 1 28496-911 Whatman 934AH - 7 cm glass fiber filters 1 EK-13062-5 H_3PO_4, 8 lb. 1 EK-04835-3 NEDA, 25 g 1 EK-13063-5 H_2SO_4, 9 lb. 1 EK-04378-7 Sulfanilamide, 500 g 1 EK-01599-6 Triethanolamine, 250 g 1 EK-00865-7 $Na_2Cr_2O_7$, 500 g	VWR Scientific, Inc. (see above)

Item Selected in 10/21/82 Design Review Meeting	Item Ordered	Vendor
1 Analytical balance	1 Mettler AE-160 electronic balance cat. no. 11274-609	VWR Scientific (see above)
5 Dust pumps, chargers, and respirable dust head assemblies	2 Bendix C115 pumps w/batteries, chargers, and sampling heads (2 only available) 3 DuPont P4000 constant-flow samplers with chargers 3 Bendix 2418543-001, BDX 99 respirable dust lapel samplers to be used with DuPont pumps	Argus Supply Co. (see above)
100 Filter cassettes (Gelman 4339)	1 pkg of 100 three-piece field monitors	MDA Scientific, Inc. (see above)
1 10 mm nylon cyclone in side arm tube	1 Bendix 2418543-001, BDX 99 respirable dust lapel sampler	Argus Supply Co. (see above)
1 Bubble meter setup for dust pump calibration	1 ECC 4-07-2000 pump calibrator	Argus Supply Co. (see above)
1 Manostat with enclosures	One 32981-003 manostat glove box 1 pair 41-905-008 front glove box closures	VWR Scientific (see above)
1 Humidity gage, pans of humidity control chemicals & shelves for manostat	One 35521-054 Durotherm hygrometer One JT-4344-5 $Zn(NO_3)_2 \cdot 6H_2O$, 5 lb.	VWR Scientific (see above)
1 Microbalance	1 Perkin Elmer AD-2B electronic Ultramicrobalance, part no. C-322-0033 1 stirrup, 56 mm, for filter weighing, part no. C-322-0069	Perkin Elmer Corporation 431 Stephenson Highway Troy, MI 48084

APPENDIX II

Performance Test Results

Instrument Stability

Continuous instruments were purchased for CO, CO_2, NO and NO_2.

Performance testing of the Ecolyzer 2106 CO instrument and the Ecolyzer 7230 NO and NO_2 instrument was assessed primarily by operating the instruments for 6-7 hours in the laboratory, then charging the batteries overnight, combined with twice-daily checks for zero and span drift. The results were as follows:

Ecolyzer 2106 CO Instrument.

Table II-1 lists the results of the stability test on this instrument which was performed over a three day time period. The tabulated values show that without any adjustments over the three day test, the zero changed only on the first day and the change was only 1 ppm. Morning readings on the span gas dropped from 38.0 ppm the first day to 36.5 on the third day while afternoon readings dropped from 37.2 to 35.5 ppm. Each day the span gas readings dropped by about 1 ppm during the 6 to 7 hours of operation. These results are about what we would anticipate, based on our earlier experiences with a similar instrument.

Ecolyzer 7230 NO-NO_2 Instrument.

Table II-2 lists stability data for this instrument. There was a need for zero adjustments of only -0.2 ppm the second morning and 1.5 ppm on the third morning. There was essentially no zero drift during operation nor did the span change significantly. However, with no span adjustment over the three day period, the span gas reading dropped from 38.0 to 36.5 in the morning and from 37.2 to 35.5 in the evening. These results are also about what we would expect on the basis of our earlier experiences with a similar instrument.

Table II-1
Ecolyzer 2106 CO Instrument Stability Record

Instrument
Model: 2106
Gas: CO
Serial No. 2645

			Morning Check**							Afternoon Check**						
			Time of Day			Zero gas		Span gas*, Conc.=38.8		Time of day	Zero gas		Span gas* Conc.=38.8		Flow	Time of Day
	Date	Conc. Range	Off Charger	Turn On	Cal. Check	Reads	Adj to	Reads	Adj to	Cal. Check	Reads	Adj to	Reads	Adj to	rate, SCFH	Turn Off	On Charger
Electro-chemical Cell	1/26/83	Low															
Serial No. 16723	1/26/83	High	8:30	8:30	9:30	-	0	38.0	-	2:47	-1/2		37.2				
Date Installed 1/25/83	1/27/83	Low									-1	0	37.0	-	1.45	2:52	2:52
Inter-ference Filter						-.003		36.5			-.014		36.8				
	1/27/83	High	8:10	8:10	9:25	-.003	-	36.2	-	2:20	-.007		36.5	-	1.40	2:30	2:30
Number 1	1/31/83	Low				0.00		36.5			0.00		35.5	-			
Date in-installed 1/25/83	1/31/83	High	8:15	8:15	8:30	0.00	-	36.5	-	2:55	0.00		35.5	-	1.35	3:00	3:00

*Conc. in ppm

**Instructions: Morning check - remove from charger, turn on, warm up 15 minutes, then check. Leave on battery operation at least 6 hours before making evening check. Turn off and put back on charger.

Table II-2
Ecolyzer 7230 NO Instrument Stability Record

Instrument
Model: 7230
Gas: NO
Serial No. D-1051

			Morning Check**							Afternoon Check**						
			Time of Day			Zero gas		Span gas*, Conc.=40.74		Time of day	Zero gas		Span gas* Conc.=40.74		Flow	Time of Day
	Date	Conc. Range	Off Charger	Turn On	Cal. Check	Reads	Adj to	Reads	Adj to	Cal. Check	Reads	Adj to	Reads	Adj to	rate, SCFH	Turn Off	On Charger
Electro-chemical Cell	1/26/83	Low									-.2						
Serial No. 0558	1/26/83	High	8:30	8:30	10:00		0	40.0	-	3:00	0	-	38.6	-	1.4	3:05	3:05
Date Installed 1/25/83	1/27/83	Low				-.2					0						
Inter-ference Filter	1/27/83	High	8:10	8:10	10:00	-.2	0	40.0	-	2:24	0		38.5	-	1.45	2:30	2:30
Number 1	1/31/83	Low				+1.2					-2						
Date in-installed 1/25/83	1/31/83	High	8:15	8:15	8:45	+1.5	0	40.0	-	3:00	-2	0	33.5	-	1.40	3:00	3:00

*Conc. in ppm

**Instructions: Morning check - remove from charger, turn on, warm up 15 minutes, then check. Leave on battery operation at least 6 hours before making evening check. Turn off and put back on charger.

Table II-3 lists stability data for the NO_2 instrument side of the 7230. This instrument was very stable during the 3-day test and there was no need to adjust either zero or span.

CO, CO_2, NO and NO_2 Calibration Gases

Cylinders containing approximately 140 cubic feet at STP of each of these gases were purchased from Scott Specialty Gases Inc. NBS standard reference gases were purchased for CO, CO_2 and NO only. None is available for NO_2.

The commercial Scott gases were compared with the available NBS standards. NO_2 was compared with Michigan Technological University gases purchased from Scott at an earlier date. The comparisons were made by first zeroing the instrument (CANMET Ecolyzer 2106 for CO, CANMET Ecolyzer 7230 for NO and NO_2 and MTU Fuji ZFP5 for CO_2) with the new CANMET zero gas purchased from Scott. Then the new CANMET NBS standard gas was fed in and the instrument calibrated. Next the Canmet calibration gas purchased from Scott was fed in. MTU gases purchased from NBS earlier were also included in some of the comparisons.

The results listed in Tables II-4 through II-7 indicate that all the concentrations agreed very well except NO_2. The nominal concentration of the Scott gas was 3.58 ppm, but our tests indicated that it was in the 4.3-4.4 ppm range. This discrepancy was brought to the attention of the manufacturer who stated that the 3.58 ppm nominal concentration had been erroneously reported due to a mixup. The manufacturer's analysis had shown the concentration to be 4.0 ppm rather than 3.58. We recommend that the value of 4.35 found in our comparisons be used since it is based on comparisons with MTU cylinders in which we have much greater confidence.

Table II-3
Ecolyzer 7230 NO_2 Instrument Stability Record

Instrument Model: 7230 Gas: NO Serial No. D-1051	Date	Conc. Range	Morning Check** Time of Day: Off Charger	Turn On	Cal. Check	Zero gas: Reads	Adj to	Span gas*, Conc.=4.35: Reads	Adj to	Afternoon Check** Time of day Cal. Check	Zero gas: Reads	Adj to	Span gas* Conc.=4.35: Reads	Adj to	Flow rate, SCFH	Time of Day: Turn Off	On Charger
Electro-chemical Cell	1/26/83	Low									.02						
Serial No. 1145	1/26/83	High	8:30	8:30	10:15	-	0	-	4.35	2:54	0	-	4.32	-	1.4	2:58	3:00
Date installed 1/25/83	1/27/83	Low				0					0						
Inter-ference Filter	1/27/83	High	8:10	8:10	10:05	0	-	4.30	-	2:26	0	-	4.25	-	1.4	2:30	3:30
Number 1	1/31/83	Low				-.04					0						
Date in-installed 1/25/83	1/31/83	High	8:15	8:15	8:40	-.04	0	4.22	-	3:05	0	-	4.31	-	1.4	3:00	3:00

*Conc. in ppm

**Instructions: Morning check - remove from charger, turn on, warm up 15 minutes, then check. Leave on battery operation at least 6 hours before making evening check. Turn off and put back on charger.

Table II-4
Calibration Gas Checks

Gas: CO
Reference: CANMET NBS CO-24.32 ppm
Cylinder:

Gas	Instrument Used
CC:	ESI 2106 SN 2645 CANMET
CO_2:	Fuji ZFP5 SN 9J0012T MTU
NO&NO_2:	ESI 7230 SN D-1051 CANMET

Date	Time	Gas	Cylinder	Nom. Conc.,ppm	Reads,ppm
1/26/83	9:00	N_2	CANMET Zero N_2	0	Set 0
1/26/83	9:10	CO	CANMET NBS	24.32	Set 24.32
1/26/83	9:18	N_2	CANMET Zero N_2	0	Set 0
1/26/83	9:20	CO	CANMET NBS	24.32	Set 24.32
1/26/83	9:21	CO	MTU NBS	95.0	95.6
1/26/83	9:31	CO	CANMET Scott	38.8	38.0

Instructions - For each check follow order below -

MTU zero gas → CANMET zero gas → MTU NBS → CANMET NBS → CANMET Scott

Instrument should be warmed up 15 minutes prior to checking gases.

Table II-5
Calibration Gas Checks

Gas: CO_2
Reference: CANMET NBS - 0.501% CO_2
Cylinder:

Gas	Instrument Used
CO:	ESI 2106 SN 2645 - CANMET
CO_2:	Fuji ZFP5 SN 9J0012T MTU
$NO\&NO_2$:	ESI 7230 SN D-1051 CANMET

Date	Time	Gas	Cylinder	Nom. Conc.,%	Reads,%
1/26/83	10:54	Zero	CANMET Scott Zero	0	Adj to 0
1/26/83	10:55	CO_2	NBS	0.501	Adj to 0.50
1/26/83	10:57	CO_2	CANMET Scott	0.40	0.40

Instructions - For each check follow order below -

MTU zero gas → CANMET zero gas → MTU NBS → CANMET NBS → CANMET Scott

Instrument should be warmed up 15 minutes prior to checking gases.

Table II-6
Calibration Gas Checks

Gas: NO
Reference: CANMET NBS 19.30 ppm
Cylinder:

Gas	Instrument Used
CO:	ESI 2106 SN2645 - CANMET
CO_2:	Fuji ZFP5 SN 9J0012T MTU
$NO\&NO_2$:	ESI 7230 SN D-1051 CANMET

Date	Time	Gas	Cylinder	Nom. Conc., ppm	Reads, ppm
1/26/83	9:55	Zero	CANMET Scott 0	0	Set to 0
1/26/83	10:00	NO	CANMET NBS	19.30	Set to 19.30
1/26/83	10:01	NO	MTU NBS	47.9	47.5
1/26/83	10:04	NO	CANMET Scott NO	40.74	40.0

Instructions - For each check follow order below -

MTU zero gas → CANMET zero gas → MTU NBS →CANMET NBS → CANMET Scott

Instrument should be warmed up 15 minutes prior to checking gases

Table II-7
Calibration Gas Checks

Gas: NO_2
Reference: Scott 2.6 ppm
Cylinder: Chkd 8/26/82
& Scott 4.25 ppm

Gas	Instrument Used
CO:	ESI 2106 SN 2645 - CANMET
CO_2:	Fuji ZFP5 SN 9J0012T MTU
$NO\&NO_2$:	ESI 7230 SN D-1051 CANMET

Date	Time	Gas	Cylinder	Nom. Conc.,ppm	Reads,ppm	
1/26/83	10:12	Zero	CANMET Scott	0	Set to 0	
1/26/83	10:14	NO_2	MTU Scott	4.25	Set to 4.25	
1/26/83	10:15	NO_2	MTU Scott	2.65	2.35*	
1/26/83	10:16	NO_2	CANMET Scott	3.58	4.62	
1/26/83	10:19	Zero	CANMET Scott	0	0	
1/26/83	10:20	NO_2	MTU Scott	4.25	4.50	Adj to 4.25
1/26/83	10:21	NO_2	MTU Scott	2.65	2.30*	
1/26/83	10:22	NO_2	MTU Scott	2.65	2.30*	
1/26/83	10:23	NO_2	MTU Scott	4.25	4.30	Adj to 4.25
1/26/83	10:24	NO_2	MTU Scott	2.65	2.30*	
1/26/83	10:25	NO_2	CANMET Scott	3.58	4.40	
1/26/83	10:26	NO_2	CANMET Scott	3.58	4.31	

Instructions - For each check follow order below -

MTU zero gas → CANMET zero gas → MTU NBS → CANMET NBS → CANMET Scott

Instrument should be warmed up 15 minutes prior to checking gases

*Evidently conc. dropped since last tested 8/26/82

Portable Cylinder Stabilization

One of the items of concern was to provide Canmet with portable conditioned cylinders into which gases from the larger cylinders could be transferred (see section on safety considerations). Our past experience has shown that conditioning the cylinders is not a problem except for NO_2. NO, CO, and CO_2 usually hold up well for long periods of time as can be verified by occasional concentration comparisons of the gases from the portable cylinders with the gases from the large cylinders.

Because of this concern for NO_2 stability, we requested that Scott put a small quantity of approximately 50 ppm NO_2 into the cylinder designated for NO_2 (approximately 4 ppm) to condition the walls. Our experience with this cylinder is documented below.

Record of Conditioning of D Size Cylinder for NO_2

1-03-83 Filled (200 psi) w/Scott actually 4.35 ppm NO_2.

1-26-83 Checked - reads 0 ppm

1-26-83 Filled (200 psi) w/Scott 110 ppm NO_2.

2-03-83 Emptied and filled w/Scott 4.35 ppm NO_2.

2-04-83 Reads 0 ppm - emptied and filled w/Scott 4.35 ppm NO_2

2-07-83 Reads 0 ppm. Filled (1200 psi) w/Scott 110 ppm NO_2.

2-17-83 Emptied and filled w/Scott 4.35 NO_2 (1200 psi).

3-01-83 Checked - NO_2 reads 3.0 ppm.

3-03-83 Checked - NO_2 reads 2.95 ppm.

3-07-83 Checked - NO_2 reads 2.7 ppm.

3-07-83 Emptied cylinder and filled w/Scott 4.35 pm NO_2. Shipped to CANMET.

Apparently the cylinder is now quite stable, but it will need to be checked from time to time in the future. As long as

NO_2 in the 4 ppm range is the only gas for which this cylinder is used, it would be expected to become more stable as time passes.

Rustrak Recorders

Various data on the recorders are presented in Table II-8. We were unable to purchase exactly the same recorders as we have used in our U.S. Bureau of Mines research. Thus, electronic modifications to adjust the chart speed to the exact desired value were not as easy as we had expected. Thus, long range chart speed checks (Table II-8) on Recorders 1 and 2 gave values of 32.1 and 31.7 inches per hour respectively. Our aim had been 32 inches per hour, but the difference is felt to be acceptable. Long range chart speed checks on recorders 3 and 4 gave values of 16.2 and 16.3 inches per hour. These error percentages are a little larger than those for 1 and 2, but are also felt to be acceptable.

Two of the recorders were modified to also accept a higher impedance signal. This is necessary when using the recorder with the Fuji CO_2 instrument.

It is a relatively simple matter to change the signal voltage from 0-1 volt to 0-100 mv or in the reverse direction on any of the recorders provided.

Particulate Matter Pumps

Performance data on these are presented in Table II-9. The left section of Table II-9 covers checks at 1.7 liters per minute which is the flow rate in U.S. metal mines to get the proper split between "respirable" and "nonrespirable" particulate. The pumps were set to sample at about 1.7 liters per minute as

Table II-8 Rustrak Recorder Data

Recorder No. Label	Recorder No. Serial	Motor: Voltage: Battery	Motor: Voltage: Regulated	Motor: Voltage: Adjusted	Motor: Nominal Speed rpm	Gear Train No.	Chart Speed in/hr: Nom	Chart Speed in/hr: At 6v	Chart Speed in/hr: At Adj. Voltage	Meter Movement: Model No.	Meter Movement: Signal Voltage	Meter Movement: Impedance: Nominal	Meter Movement: Impedance: Modified to	Instrument for
1	N310239	12	6	OK at 6	16	4	32	32	-	AA 102-101-1A	0-1	Low	-	ESI instruments
2	N310240	12	6	6 w/1.5k resistor	16	4	32	33.5	31.73	AA 102-101-1A	0-100	Low	High	Fuji ZFP5 or ESI instruments
3	N310242	12	6	"	16	2	16	16	-	AA 102-101-1A	0-1	Low	-	ESI instruments
4	N310243	12	6	"	16	2	16	16	-	AA 102-101-1A	0-1	Low	High	ESI instruments or other high impedance 0-1 volt signal output instrument.

LONG RUN SPEED CHECKS

Label		
1	6.3 hours gave 202.25 inches or 32.1"/hr	Zero=0 38.6 ppm read 38.6
2	2.9 hours gave 92.0 inches or 31.72"/hr	Zero=0
3	3.87 hours gave 62.75 inches or 16.21"/hr	Zero=0 37 ppm reads 37 ppm
4	4.67 hours gave 76 inches or 16.3"/hr	Zero=0 92 ppm CO reads 90 ppm

Table II-9
Particulate Matter Pump Performance Data

Model	Pump Number Label	Pump Number Serial	Particulate Matter Collection Performance check - Flowrate, liters/minute: Time of Day	Clean 37 mm A/E filter- 2"H_2O	Restriction 10"H_2O	Restriction 25"H_2O	Gas Sample Collection Pump Performance Check: Time of day	Maximum Flowrate, Lpm Restriction, in. of H_2O 0	5	10	CO_2 conc.* Into Pump, %	Out of Pump, %	Lag time, sec.
Dupont P4000	1	B279	9:30 3:30	1.704 1.692	1.704 1.680	1.704 1.669	9:25	5.618	5.199	4.902	0.40	0.40	14.98
Dupont P4000	2	B280	9:30 3:30	1.685 1.669	1.685 1.667	1.667 1.661	9:45	5.357	4.918	4.587	0.40	0.40	15.76
Dupont P4000	3	B281	9:30 3:30	1.695 1.679	1.695 1.676	1.685 1.663	10:00	5.405	5.199	4.878	0.40	0.40	15.38
Bendix C115	1	1825	10:30 4:00	1.695 1.738	1.339 1.359	0.758 0.774	10:15	4.317	3.876	3.394			
										Small bag	0.40	0.395	19.28
										Big bag	0.40	0.395	
Bendix C115	2	06-80-21	10:30 4:00	1.716 1.692	1.486 1.479	1.107 1.092	10:30	3.851	3.513	3.108			
										Small bag	0.40	0.395	21.42
										Big bag	0.40	0.40	

*Setup:

Bag of gas → Pump → 100' of 1/4" ID tubing → Manifold (40" of 1" tubing) → Fuji ZFP5 (Drawing 1.3 Lpm)

measured by a bubble meter. They were thus restricted sufficiently to produce either 10 or 25 inches of water vacuum and run for 6 hours after which the flowrate was again measured by a bubble meter.

From the table, it is evident that neither 10 or 25 inches of H_20 restricts and significantly affects the flowrate of the Dupont p4000 pump. However, even a 10 inch restriction seriously impedes airflow into the Bendix C115. The tabulated results also show that neither the Dupont p4000 nor the Bendix C115 experiences much of a flowrate change during the 6 hours of operation. Basically, we conclude that the much more rugged Bendix C115 can only be used where particulate concentrations are not high enough to significantly increase the filter's resistance to flow. The right side of Table II-9 presents measurement data evaluating the pumps for pushing air to the Fuji instrument where we feel flow rates of at least 4 liters per minute, into a properly designed manifold, are necessary. We again see that the more rugged BDX C115 does not perform as well as the Dupont p4000. Higher flowrates are produced by the p4000 which are much less sensitive to downstream pressure restrictions.

During the above test we also checked the integrity of all pumps to determine whether any air enters the sample in the pump. This was accomplished by using the pump to transfer a CO_2 calibration gas, the concentration of which was known, from one bag to another. The results indicate that each pump puts out essentially the same concentration that it takes in.

Dupont P-125 Bag Sampling Pumps

Performance data on these three pumps are listed in Tables II-10 and II-11. From the Table II-10 results we can see the effect of changing the resistance from 0 to 25 inches of water at flowrates as near the minimum and maximum values as we were able to set and hold. Significant flowrate decreases occur with changes from both 0 to 10 and 10 to 25 inches of water.

Table II-11 shows the effect of 6 hours of operation on the flowrate setting at all three flow resistance levels.

Only slight changes occur over 6 hours operation for all three restriction levels and for both minimum (approximately 25cc/min) and maximum (approximately 125cc/min) flow rates. The tendency appears to be for slight decreases, but in some cases the flowrates actually increased.

The unrestricted flowrates are most indicative of bag sampling conditions for which we intend to use the p125 pumps. The small flowrate changes measured will, most likely, have no significant effect on the bag concentrations and we feel that the pumps performed satisfactorily.

Sequoia Turner Model 340 Spectrophotometer

The Sequoia Turner Model 340 spectrophotometer is used in the Palmes' NO_X-NO_2 analysis. A series of standard $NaNO_2$ solutions were prepared to test the performance. Table II-12 shows the concentration levels of $NaNO_2$ added to make a total volume of .02 ml in Palmes' analysis reagent, along with percent transmittance and calculated absorbance values [$-\log_{10}(\%T/100)$].

Table II-10
Dupont p125 pump flowrate limits check

Date 1/28/83

Pump Number		Flow Rate	Flow rate, cc/minute		
				Restricted	
Label	Serial	Limits	Unrestricted	10"H_2O	25"H_2O
1	12711	Minimum	32.43 26.20	30.30 23.81	27.09 21.28
		Maximum	120.0	118.4	112.5
2	12713	Minimum	27.27	24.79	22.64
		Maximum	128.57	126.76	114.65
3	12726	Minimum	26.30	25.00	21.43
		Maximum	120.0	118.42	112.5

Test setup

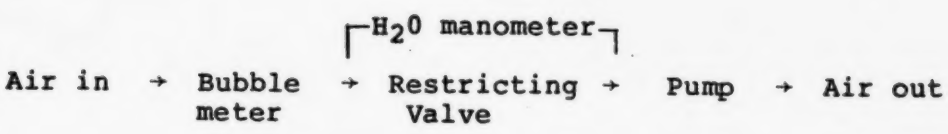
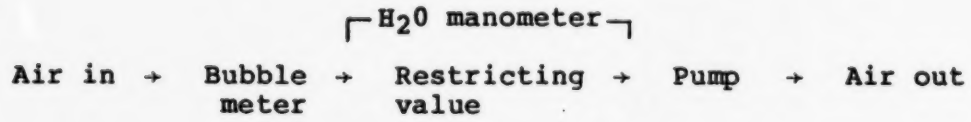


Table II-11
Dupont P-125 Pump Flowrate Stability Check

Pump Number		Flowrate, cc/min.					
		Initial			After 6 hours		
		Unre-	Restricted		Unre-	Restricted	
Label	Serial	stricted	10"H_2O	25"H_2O	stricted	10"H_2O	25"H_2O
1	12711	25 (26.6)*	24.4	21.4	26.0	23.8	21.1
2	12713	25 (26.5)*	24.1	22.3	26.1	24.2	21.7
3	12726	25 (28.6)*	27.9	24.4	29.2	28.2	25.5
1	12711	125(125.0)*	121.6	116.9	120.0	118.6	113.9
2	12713	125(134.3)*	128.6	115.4	131.7	126.8	104.9
3	12726	125(121.6)*	118.4	114.6	123.4	120.8	116.7

Test Setup



( )* Actual flowrate used

Table II-12 calibration standards for Model 340 spectrophotometer: Concentrations, percent transmittance, and calculated absorbance.

Cuvette Number	Nanomoles NO_2 Added	%T Read	A, Calculated
1	5	80.9	.092
2	5	77.4	.111
3	10	64.5	.190
4	10	58.8	.231
5	20	39.7	.401
6	20	33.5	.475
7	40	14.9	.827
8	40	13.8	.860
9	80	2.0	1.699
10	80	2.1	1.678

According to Beer's law, absorbance is linearly related to concentration. This law is followed very well for the concentration range tested here, and for the wavelength monitored (550nm). The data indicate that the spectrophotometer performs well for the dye produced in the Palmes' sampler analysis.

Perkin Elmer AD-2B Ultramicrobalance

The Perkin Elmer AD-2B ultramicrobalance was performance tested first by the standard instrument checks designated by the manufacturer. The instrument was turned on and warmed up for 3 hours. Zero agreement and range agreement were within specifications, and small adjustments were made to the autozero high count and autozero low count controls.

After calibrating the balance using the 100 mg class M weignt provided with the balance accessory kit, two sets of weights, also included, were used for further checks. Table II-13 shows the displayed values for both weight sets with the balance in the "autorange" positon as well as in the range appropriate for the weight examined.

Table II-13 Displayed Values for Weight Sets with Balance in Autorange Position

Nominal Mass, mg	Autorange Value	Other Range Value
1	1.0690	1.0685
2	1.9635	1.9620
2	1.9945	1.9950
5	5.016	5.015
10	9.9958	9.9958
20*	19.909	19.906
20*	20.05	20.05
50	50.11	50.10
100	100.10	100.10
200*	199.46	199.45
200*	200.3	200.3
500	500.7	500.6

*Different weights

There seems to be good agreement between the range settings used, and no more than 6.9% error on the lightest weight measured (1 mg). Since the weight sets in the accessory kit are not class "M" (secondary standard), the deviation is likely to be in the weights rather than in the balance, Based on these criteria, the microbalance was deemed to be performing acceptably.